On Circulation in Plants. By A. Trécul. (Second Part*.)

During the life of a plant all the liquids are in motion in each of the utricles of which it is composed, either to carry into these the elements necessary for their growth, or for the formation of the amylaceous, saccharine or albuminoid principles, &c., to which they give origin, or to remove from them those substances which have become useless and which require to be eliminated, or those which have to be carried to other parts of the plant to serve for the multiplication of the cells and the growth of the individual. It is this general movement that constitutes the circulation; but this name is usually given to definite currents, more perceptible than this general intracellular movement, which traverse the plant through its whole length from top to bottom and from the bottom to the top.

It is to this double current that I give the name of the *great circulation.* I have also indicated the *venous circulation,* which takes place, as I have stated, in the laticiferous vessels.

The great circulation is observed in all vascular plants; but the laticiferous vessels have not yet been detected in all plants which possess vessels.

The great circulation therefore consists of an ascending current of the sap, and of a descending current. Let us first of all take the former into consideration. It takes place in the vessels which receive and elaborate the juices drawn from the soil by the roots. When this ascent commences, all the cells are at work. The nutritive substances which they contain arrange themselves by assimilation. Starch, dissolved no doubt by diastase, and converted into sugar, as has been shown by MM. Payen and Persoz, is carried to the parts where the cellular multiplication is to take place. The starch of the base of the buds serves for the alimentation of the latter; that of the bark passes into the internal cells of that part of the plant, which very probably also receives some by the medullary rays. It is under the influence of these nutritive materials that the increase in diameter by the multiplication of cells commences. This multiplication at starting really takes place without the aid of the sap elaborated by the leaves, for in many of our trees the layer of young cells (generative layer, also called cambium) acquires a considerable thickness before the appearance of the leaves.

These first phænomena make their appearance with the ascent of the sap. This, in rising, undergoes an elaboration, with which I am not sufficiently acquainted to speak of it at greater length; I shall content myself with indicating the beautiful experiments of M. Biot, which have shown us the changes which sugar undergoes during the progress of this sap. During its ascent it already contains assimilable principles which may assist in the nutrition of the leaves and buds (in which the spiral vessels make their appearance from below upwards); but in the spring these buds are indebted for their first development especially to the alimentary substances amassed in the neighbouring cells.

* See Annals, Dec. 1857, p. 467.

The sap, which on its way takes part in the nutrition of the first organs developed, arrives in the leaves, in the green parenchyma of which it is submitted to a fresh elaboration, or in the chlorophyll-cells of the stem of the fleshy plants destitute of leaves. The carbonic acid of the air is absorbed and then decomposed during the day; its carbon is retained by the sap and its oxygen in great part rejected. The sap, thus modified under the influence of respiration, takes its course through the cortical cells, which it nourishes. It then aids in the multiplication of the cells of the generative layer, which are produced in horizontal series. A portion of these cells thus horizontally multiplied forms a new layer of bark, the woody fibres and medullary rays; the others are converted into vessels in the following manner. The excess of the descending sap which is not employed in the nutrition of the newly formed cells, or in thickening those first developed, descends through certain of the newly formed cells; it dilates them, perforates them, and makes them take all the characters of vessels, so that these cells, which, during the first phase of their development, resembled all the others, appear subsequently to be of a totally different nature.

It is this vascular formation, which takes place, as we see, from above downwards, at the expense of cells originating from a multiplication in horizontal series, that has led the authors of the theory of descending fibres to believe that these vessels, of which they did not recognize the nature, were true roots of the buds or leaves.

But all the sap absorbed by the old or new cells, whether for their increase in size or thickness, or for the production of starch, albuminoid substances, &c., which are to serve for subsequent growth, is not used up by the cells. These only assimilate a part of its elements and reject the rest. It is this *caput mortuum* which, in the form of resins, essential oils, &c., is collected in peculiar reservoirs, from which it is afterwards thrown outwards *; or the unassimilated matters are taken up by the laticiferous vessels, which carry them back into the vessels properly so called (this is the *venous circulation*). There these substances, which are usually destitute of oxygen, are elaborated and oxidized by the action of the oxygen derived from the air, which penetrates even to the vessels by intercellular passages; they become again fitted for assimilation. It would be from their oxidation, as I have already stated, that the carbonic acid rejected by plants during the night would be produced; that which is produced during the day being decomposed on its passage into the leaves under the influence of light; its oxygen is poured out into the atmosphere together with that arising from the decomposition of the carbonic acid taken directly from the air by respiration.

The vessels produced by the descending sap, serve in the following years for the ascent of the juices. They are filled therewith as long as the vegetation is very active, but usually empty themselves when

* It is undoubtedly emissions of this nature and of this origin that constitute what are called the *excretions* of the roots, of which agriculture seeks to turn to account in the rotation of crops.

the juices drawn from the soil become less abundant or cease altogether.

The experiments which I described in a memoir read to the Academy on the 25th of July 1853, prove in the most evident manner the course of the descending sap; for when obstacles are opposed to the progress of this sap, by means of ligatures, or of spiral, annular, or semicircular decortications, the course of the sap may be changed at pleasure. It then gives origin to very sinuous vessels, presenting vertical parts and others oblique or horizontal, which are always formed of cells elongated vertically, that is to say, parallel to the axis of the stem, and of which the form, which is not generally changed, is similar to that of the surrounding cells. The sinuosities of these vessels show the currents of the sap progressing through the cells of the generative layer, turning in all directions to find an issue, perforating the cells from above downwards or horizontally, according as the current is vertical, oblique or horizontal.

All these facts prove evidently that it is the circulation that produces the vessels,—that is to say, that it is the function that creates the organ.

Since the circulation exists before the vessels, when there are only simple cells through the walls of which the sap filters, the objection made by some anatomists to the existence of the circulation in the laticiferous vessels, an objection founded on the cellular structure of these vessels in certain plants, does not possess the importance which they assign to it, as we see the dotted and striped vessels, &c., formed by a current of sap pre-existing through imperforate cells; and moreover these anatomists should consider that there is not a living cell which is not traversed by juices, although the great majority of these cells do not present any perforation visible by means of our most powerful microscopes. And then there are laticiferous vessels which are evidently composed of superposed cells, the transverse partitions of which present very wide apertures (the laticiferous vessels of *Musa*, formed of large cells with very thin walls, are fine examples of this).—*Comptes Rendus*, Oct. 5, 1857, p. 466.

Sepia officinalis.

To the Editors of the Annals of Natural History.

Weymouth, December 14, 1857.

Gentlemen,—The beach at Weymouth was this morning strewed with the Cuttle-bone (*Sepia officinalis*). Within the space of half a mile I believe I might have gathered a thousand. In no instance could I find a portion of the animal. Apparently there has been no weather to account for such an unusual occurrence, it having been moderate for many days, with a slight southerly wind.

This mollusk is but rarely found here, though after a storm a few stray specimens of the so-called bones are thrown up.

I am, Gentlemen, your most obedient Servant,

Robert Damon.